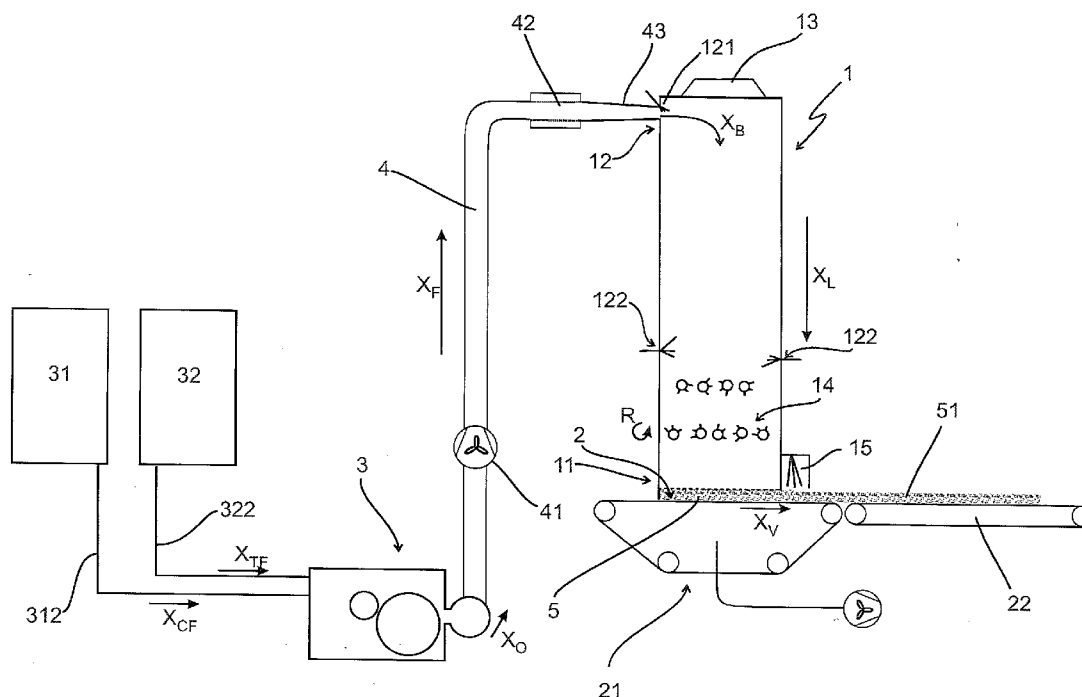


(43) **Pub. Date:** **Jul. 28, 2016**



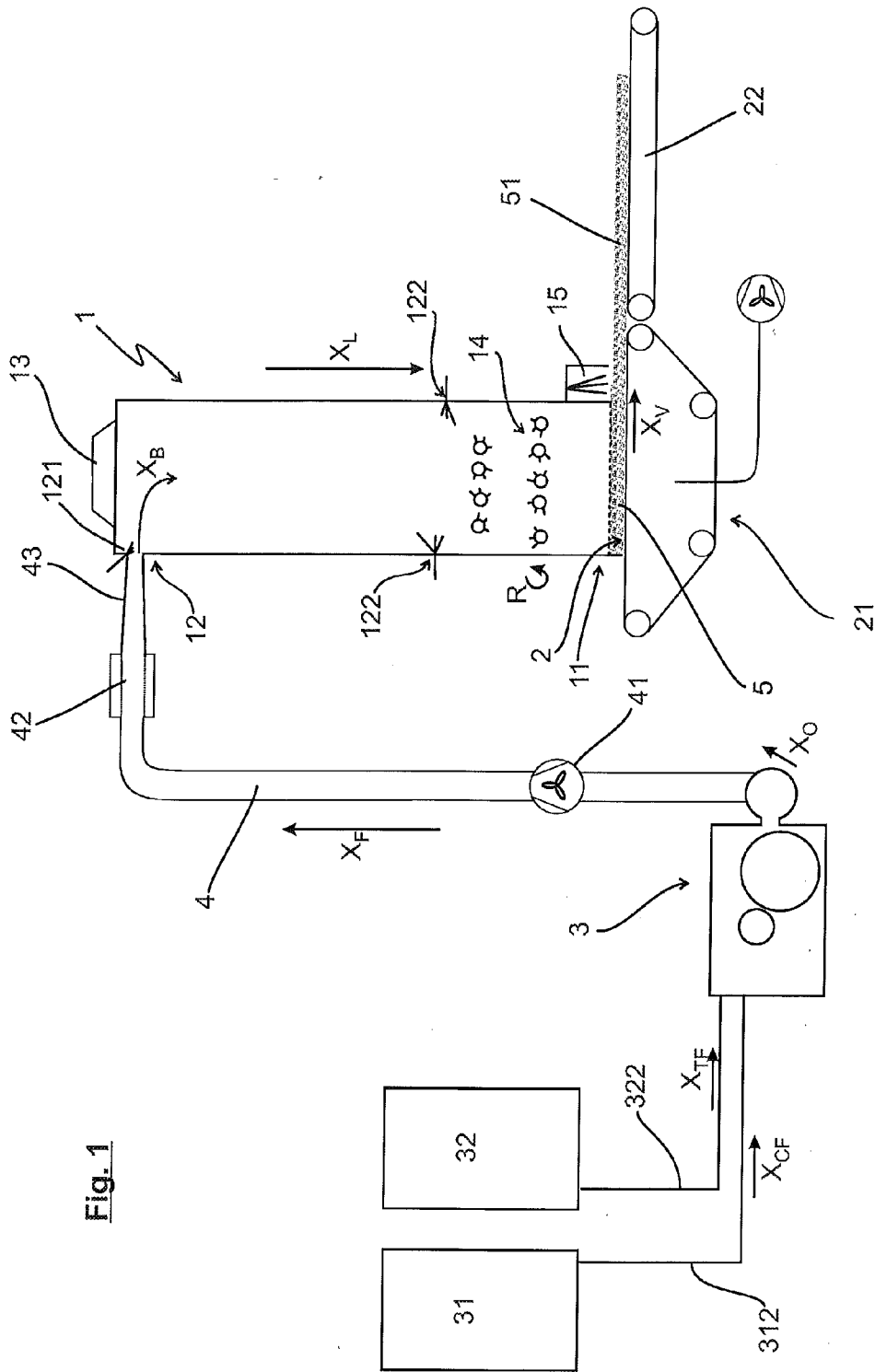
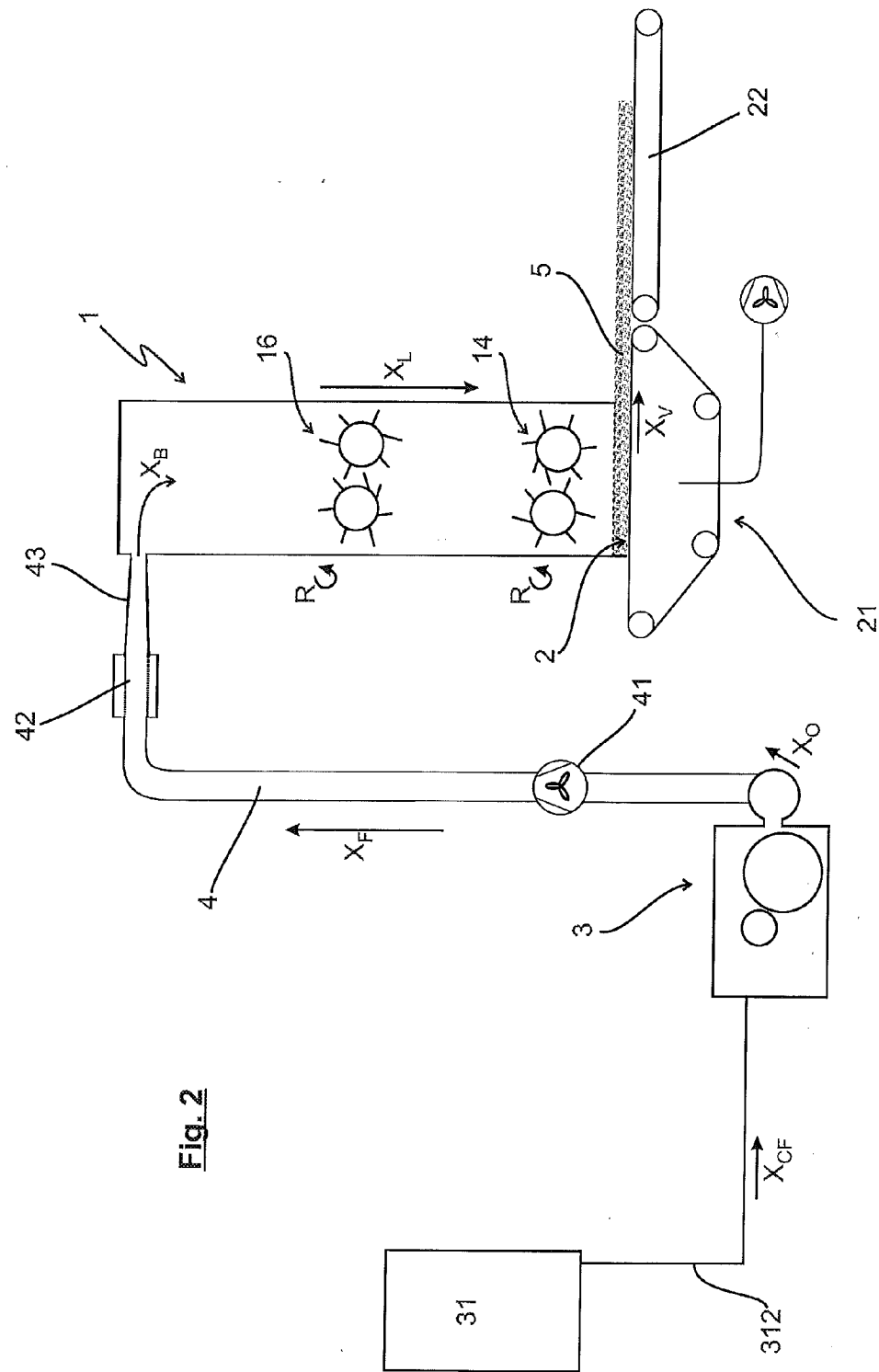
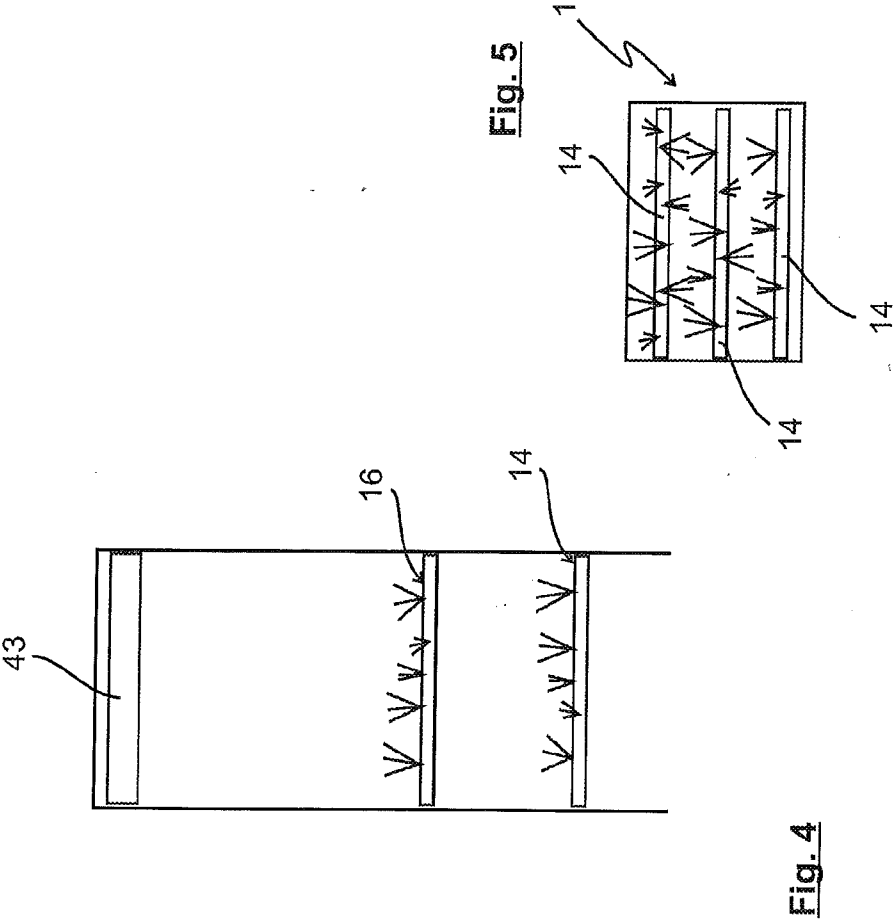
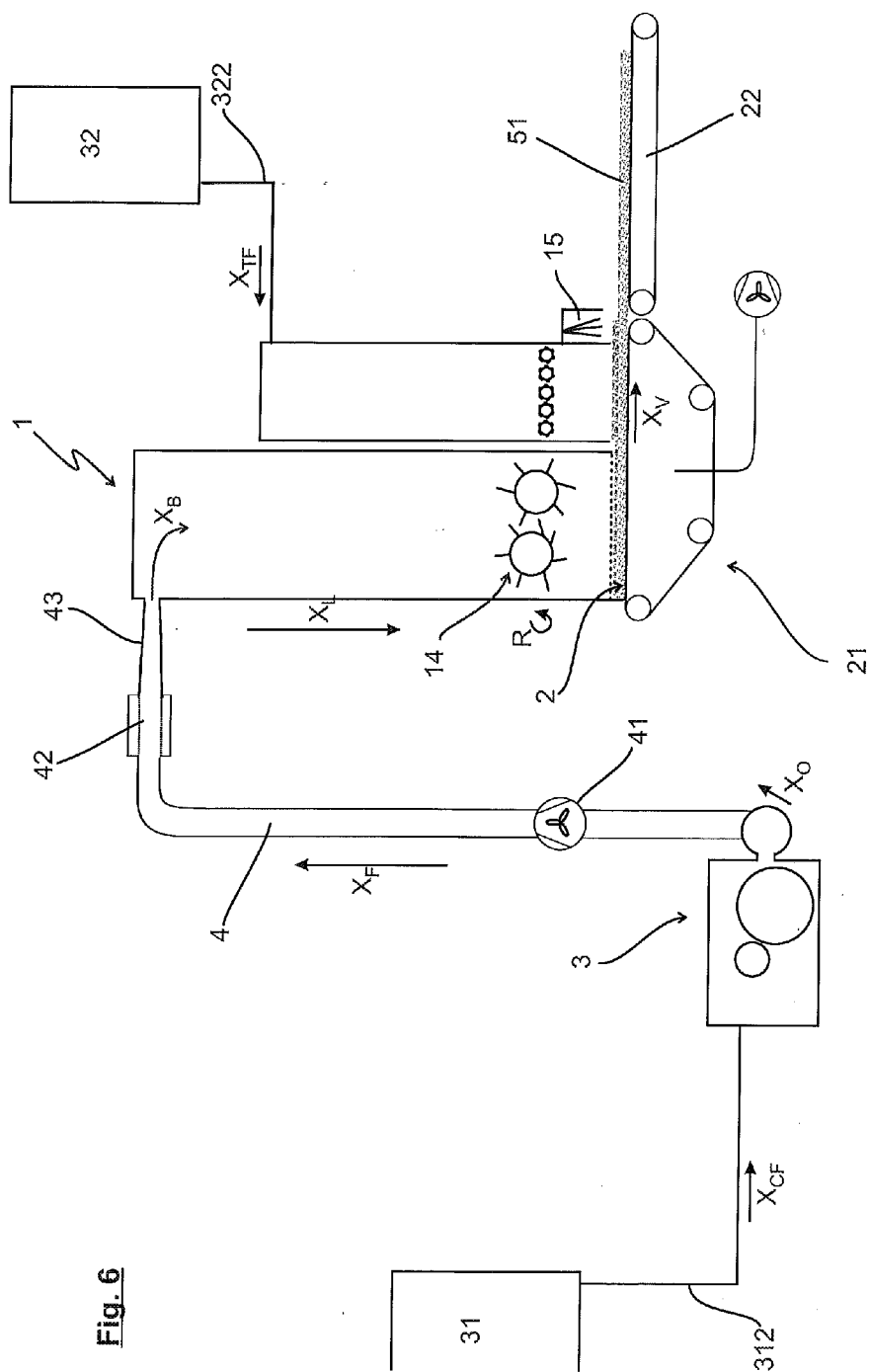
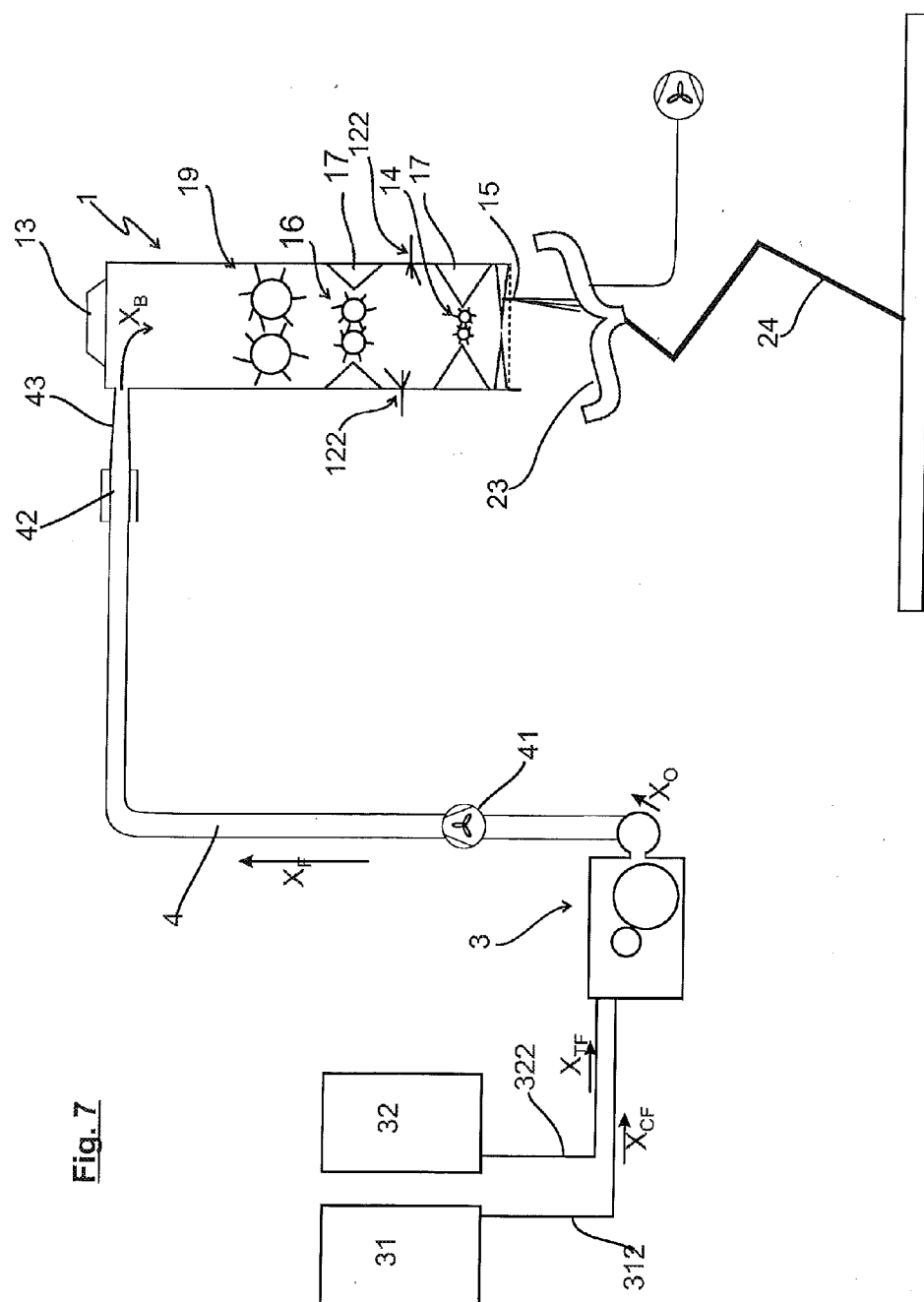


Fig. 1









**ENTANGLED CARBON-FIBER NONWOVEN
PRODUCTION METHOD AND ASSEMBLY,
THREE-DIMENSIONAL-COMPONENT
NONWOVEN PRODUCTION METHOD, AND
NONWOVEN FABRIC**

[0001] The invention relates to an entangled non-woven carbon fiber fabric or material production process and a carbon fiber manufacturing device for a random non-woven fabric or material of carbon fibers up to a fiber length of 100 mm. Furthermore, the invention relates to a method for producing a non-woven fabric or material for a three-dimensional component.

[0002] The term non-woven fabrics or materials refers to structures made of fibers of limited length, continuous fibers or chopped fibers, which in some manner are assembled and in a suitable manner joined together to form an entangled material, namely, a fibrous sheet, a fibrous mat.

[0003] Different arrangements are known in the state of the art for producing non-woven fabrics in a wide variety of configurations.

[0004] From the document EP 1 774 077 B1 a method for producing a multi-ply tissue is known, having at least one non-woven layer formed by means of an air-laid process.

[0005] From the document DE 10 2011 079 525 A1 a method for producing a fiber-reinforced plastic semi-finished product is known, wherein, for manufacture, carbon fibers are directly incorporated by a carding device, or from a feeder, into a matrix.

[0006] From the document DE 101 14 553 A1 a method for producing a thick, thermoformable, fiber-reinforced semi-finished product is known, wherein dry reinforcing fibers are mixed together by means of an air-laid or carding process to form a continuous web, wherein the web obtained is solidified by needling.

[0007] From the document DE 10 2004 051 334 A1 a method for producing a three-dimensional structure of a component is known, the latter having a dimensionally stable textile structure.

[0008] Furthermore, from document US 2013/0108831 A1, a non-woven fabric with randomly arranged fibers is known which is produced in the air-laid method.

[0009] Also, from the document DE 100 52 223 A1 a multilayer, flexible, carbon-containing layer of paper is known which is produced in the air-laid process.

[0010] In the publication by H. Fuchs, W. Albrecht "Non-wovens", published by Wiley-VCH GmbH (ISBN 978-3-527-31519-2 Print), 2nd edition 2012, page 158-171, non-woven mats and their manufacturing method is disclosed, where different systems are shown to produce these mats, and in particular the air-laid method is described.

[0011] Also known are alternative applications for a tuft feeder as disclosed in the publication Melliand Textilberichte 7-8/2001, page 567-570 of S. Schlichter, B. Rübenach, Trützschler GmbH & Co. KG.

[0012] A problem with the previously known non-woven fabrics of carbon fibers is non-uniformity with respect to the distribution of the carbon fibers within the mat. There are formed thickened areas and areas in which far too little carbon fibers are provided within a prepared mat. This non-uniformity leads to mats produced from the non-wovens parts that do not have the necessary stability over their entire structure and so quickly fail under the set requirements.

[0013] Generally known for the production of non-woven fabrics from a variety of starting fibers are in particular the

wet-laid process, wherein the fibers are present in a water bath and are formed out of this into a mat, which is generally applied for the production of carbon fiber non-wovens, and the air-laid process, where with the aid of air and needle devices or needle equipped rollers fibers are made into non-woven fabrics, but this is not applicable to carbon fibers. The application of the air-laid process to carbon fibers results in particular in mechanical operations on the fiber and, ultimately, thereby impairment of the high performance fiber.

[0014] The present invention is based on the object of disclosing an arrangement and a method for producing non-woven fabrics, which make it possible to treat the fibers to be processed gently during manufacture and in particular homogeneous and to impart requirements to the fiber in a non-woven fabric form.

[0015] These objects are achieved with a method according to claim 1, an arrangement according to claim 7 as well as a further method of claim 13 and a non-woven fabric according to claim 15.

[0016] The process of production of carbon fiber non-woven fabrics from carbon fibers up to a fiber length of 100 mm comprises the steps of:

[0017] I. supplying carbon fibers;

[0018] II. loosening/combing apart and aerodynamic separating the carbon fibers;

[0019] III. aerodynamic calming the separated carbon fibers;

[0020] IV. introducing the calmed and isolated carbon fibers into a vertically arranged air shaft, wherein the introduction is carried out at the upper end of the air shaft;

[0021] V. contactless mixing the carbon fibers within the air shaft by means of a plurality of individual air swirling air streams;

[0022] VI. aerodynamic depositing the carbon fibers on a movable mold or laying surface arranged below the air shaft, wherein the aerodynamic depositing is facilitated by a suction below the mold or the laying surface.

[0023] Through the above-indicated procedures there occurs a non-contact mixing and calming, with gentle material handling, depositing of the carbon fibers on a laydown surface or on a form, wherein during mixing no mechanical interventions take place which could damage the carbon fibers.

[0024] Inside the air shaft, following the aerodynamic or contactless mixing, a gravity-assisted trickle down of fibers takes place.

[0025] The step II according to the invention, namely, the loosening/combing apart and aerodynamic separation of the carbon fibers, can also be realized by means of an aerodynamic separation method or arrangement, wherein the loosening/combing apart is accomplished by corresponding air rollers. Alternatively, commercially available openers can be used to open the delivered carbon fiber bundles, to loosen/comb apart, in order to prepare them for further processes. A traditional opener in this case has two counter-rotating needle rollers, which are preferably formed in the case of carbon fibers with a spherical head at the needle tip.

[0026] The contactless mixing of the carbon fibers is effected within the vertically arranged air shaft (Step V.) by air swirling by a plurality of individual air streams, said air streams being varied and/or adjusted in their direction and I or strength.

[0027] The air streams in this case can be realized by a plurality of individual nozzles, wherein it is crucial that a turbulent or chaotic and especially not directed flow is formed within the air shaft.

[0028] In a particular embodiment, the air streams are generated by one or more rotating and horizontally arranged air rollers, in particular arranged within one or more planes. These can also be variably adjusted. The air rollers are designed as rotating pressure pipes, on the outer circumference of which a plurality of nozzles are arranged. Driven by respective electric motors, the air rollers are rotated, so that via the thereupon arranged nozzles, which can have different discharge angles, the discharged air is spatially distributed, so that within the air shaft to a mixing of the carbon fibers occurs.

[0029] The suction step (Step VI.) is varied and/or adjusted in the suction capacity, whereby the density of the web can be adjusted or varied accordingly. A further possibility of the density variation is adjusting the speed of an appropriately provided belt conveyor or a moving of the shape by the deposit zone by so that the density decreases with higher speed and with a reduced speed the density of the carbon fibers increases.

[0030] The shape or the deposit surface is moved past the lower outlet, the deposit zone, the air shaft, wherein the passage is guided linear or spatially, wherein the normal surface of the shape or laying surface corresponds in sections to the perpendicular of the air shaft. This means that the carbon fibers trickling down always land vertically incident on the surface of the mold and there lie down according to the surface, thereby forming a non-woven product, which corresponds exactly to the surface curvature or surface shape of the mold. The problem of the subsequent bending of a two-dimensionally generated fleece to a three-dimensional surface is hereby bypassed altogether, since a three-dimensional non-woven mat is produced directly on the form, which can be further processed as appropriate with plastics to produce a carbon fiber-plastic matrix. In the application of the fibers, these particularly preferably include a thermal bonding fiber, such as polyamide fibers, wherein the fiber mixture of carbon fibers and thermal bonding fibers are solidified immediately after the depositing on the mold by an energy or heat source such that upon further movement of the mold a changing the position of the fibers relative to each other is prevented or excluded. For this a partial melting of the thermal bonding fibers at the surface of the mat occurs, so that an advancing envelope is produced above the fabric. The composition of the fibers is here however not changed.

[0031] The carbon fibers are cut during feeding by means of a cross-cutting. In particular, carbon fibers from recycling processes are used for non-woven mat production, which are brought to a predefined length, first by means of a cross-cutting, so that overall only fibers are present with a maximum length of, for example, 60 mm.

[0032] The carbon fibers are supplemented with thermal bonding fibers during feeding. The thermal bonding fibers are partially melted by application of energy after the application of the mixture comprising carbon fibers and thermal bonding fibers onto the form or laying surface.

[0033] A carbon fiber-entangled non-woven production arrangement for carbon fibers up to a fiber length of 100 mm, but in particular for fiber lengths up to 60 mm, for carrying out the production method of the invention, comprises:

[0034] a supply arrangement for carbon fibers and, optionally, a supply arrangement for thermal binding fibers;

[0035] a loosening/combing apart device or a fiber opener for combing, separating, loosening and/or releasing the carbon fibers;

[0036] an air shaft, wherein this is arranged vertically and wherein the carbon fibers are introduced at its upper end and discharged at the lower end;

[0037] a transport and separation device for separating and transporting the separated carbon fibers from the loosening/combing apart device or the fiber opener to the air shaft, including:

[0038] a pipeline system;

[0039] an entry area of the pipeline system to the loosening/combing apart device or a fiber opener;

[0040] a transport blower or fan inside the pipeline system for transport of the carbon fibers to the air shaft;

[0041] a calming section, arranged downstream of the transport fan, designed as a perforated tube, and

[0042] an introduction section for introducing the carbon fibers in the air shaft;

[0043] a perforated deposit surface arranged at the lower end of the air shaft, in particular a conveyor belt, or a three dimensional shape for giving form to the carbon fibers to be deposited thereon;

[0044] a vacuum provided below the depositing shape or surface, and

[0045] an aerodynamic mixing system arranged in the air shaft for mixing the carbon fibers.

[0046] By means of the previously disclosed arrangement, it is possible on the one hand to realize the processes or process sections in such a way that contactless and without mechanical intervention a mixing the carbon fiber occurs in the free-flow zone, namely within the air shaft.

[0047] The aerodynamic thorough-mixing system comprises a plurality of air nozzles that generate a plurality of air streams, the air streams being variable and/or adjustable in the direction and/or strength. The air jets can for this purpose be tapered or straight and arranged differently, especially in their orientation or direction of the jet. In addition, the beam width of the nozzle can vary from nozzle to nozzle. In a particularly preferred embodiment, no engagement of the air flows within each other takes place, so that the air turbulence or air flow within the air shaft while causing a very good mixing of the fibers does not prevent their precipitation downward.

[0048] With respect to the aerodynamic through-mixing system, for this purpose, a variety of possible spray shapes are available for generating an optimal vortex within the air shaft, so that the fibers can be optimally mixed and uniformly, in particular with uniform concentration, trickle down.

[0049] The fibers are blown and swirled by the aerodynamic through-mixing system from various quarters.

[0050] The laying surface is formed perforated, wherein a vacuum or suction device, for example, a transport fan, is provided below the laying surface, which quasi suctions the trickling and isolated carbon fibers onto the laying surface. Of course, this suctioning of the fibers is carried out only on a defined area below the trickle zone.

[0051] The air nozzles are rotated about one or more axes and/or swiveled and/or are designed differently in their nozzle outlet.

[0052] The air nozzles are provided on horizontally arranged rotating rollers. The air nozzles in particular are arranged on the rotating rollers to form air rollers according to the invention, which are rotated by means of motors arranged on the outside of the air shaft, in particular electric motors.

[0053] In a particular embodiment of the air rolls, the air nozzle can simply radiate into the upper portion, which this is realized, for example, by the fact that, essentially semicircular formed sheets are positioned inside the rotating rollers, a hollow tube, which during the rotation of the air rollers prevent air flow to the nozzles arranged on the rotating rollers, in that they block access to the nozzles arranged on the rotating rollers. In this way the air flow generated is directed only in the direction of the upper part of the air shaft. Below the rollers, thus, unimpeded air settling of the fibers on the mold or laying surface and the conveyor belt is possible.

[0054] As a further special embodiment of the air rollers, their complete rotation can be mentioned, which air is emitted in all directions through their full range of rotation. The air can be emitted at low speeds from the nozzles, however, due to the large number of provided nozzles, lead to an optimal turbulence.

[0055] The neck area and/or the pipeline section has internal grooves and/or baffles which cause a circular movement of the carbon fibers. Due to the clever arrangement of the extension portion of the pipeline system to the opener or the loosening/combining device, namely the lateral discharge of the opened fibers from the loosening/combining device in a pipeline system, the transport is carried out freely because of air turbulence, namely the fibers are airborne. This is done in particular by the rotating flow that comes about due to the grooves in the pipe wall.

[0056] In the calming tube section, which is arranged after the transport fan, calming of the fibers is carried out, so that their kinetic energy is reduced considerably. The calming tube section is designed as a sheathed perforated pipe and flows into an introductory section, which fans out, for example, of a round transport tube into a rectangular opening in the air shaft and so introduces calmed fibers in the air shaft.

[0057] Within the air shaft, an appropriate aerodynamic mixing takes place, so that the fibers can trickle freely downwards to the lower part of the air shaft.

[0058] Within the air shaft an air roller unit may be provided arranged in the lower part, to which end two or more air rollers are arranged parallel to each other. In one particular embodiment, five air rollers are arranged side by side.

[0059] In a further embodiment, in a further level above the first air roller unit, which is located near the lower portion of the air shaft, a second and/or third air roller unit can be provided, in which case in each case provided at least one or more air rollers respectively are disposed parallel to each other. The pre-levels are used for pre-mixing of the fibers.

[0060] Further, baffles can be arranged inside the air shaft, which first produce a concentration of the fibers in one area, which fibers are then better distributed by the arranged air rollers.

[0061] Further, rotating or stationary nozzles having identical or preferably differently streaming properties may be arranged on the inner wall of the air shaft, to optimize the mixing without mechanical intervention, in further another embodiment.

[0062] For the movement of the mold or shape below the air shaft a robotic arm device is provided, wherein the robotic arm device allows three-dimensional movement of the mold below the air shaft.

[0063] A heat source is disposed at the lower end of the air shaft so that the thermal bonding fibers can be heated after settling on the form or the laying surface to solidify the surface of the web. Such heat sources may be, for example, infrared emitters and microwave emitters.

[0064] In one embodiment, the carbon fibers and the thermal bonding fibers can be applied separately from each other onto the laying surface, wherein first the carbon fibers and, following in the transport direction of the conveyor belt, the thermal bonding fibers settle. Here, it is also possible that the thermal bonding fibers are provided in the air shaft homogenized using conventional nail rollers and sprinkled on the surface.

[0065] A further particular embodiment, in relation to the invention, is given when a method for producing a non-woven fabric for a three-dimensional component includes a step, in that a shape of the three-dimensional component is guided past a fiber output, in particular with an arrangement according to the invention, wherein the fibers are applied from the fiber output on the incidence of mold in the direction normal of the surface. This ensures that the downward trickling fibers form a mat on the surface of the mold, which exactly follows in accordance with the shape of the mold, with no tension of the fibers caused by, for example, buckling, bending or the like, which is usually occurs when laying a two-dimensionally manufactured fleece on a curved shape. Conventionally corresponding three-dimensionally formed shapes are covered with a two-dimensional non-woven mat and then processed with a plastic into a fiber plastic matrix. Such components can be, for example, the floor of a vehicle or doors of baggage compartments of overhead compartments on planes, wherein these embodiments are to be considered only by way of non-limiting examples. Since the fibers are formed into a non-woven mat exactly adapted to the shape during laying, in this way the production of a nearly tension-free component is accomplished.

[0066] The speed of movement of the mold can be varied and/or a suction device below the mold can be varied. As a result, the density of the web is adjustable. At higher suction the material in the form of fibers flowing in the trickle zone increases, so that the density of the web increases. At faster movement of the mold, the density is locally reduced, since fewer fibers can trickle per time onto the mold.

[0067] It is also possible during the passage of the mold passing below the trickle zone to apply suction to only specific portions of the mold, so as to bias attachment of the fibers at defined locations of the mold. Alternatively, individual sections of the form can have greater application of suction, to provide localized sections of the fleece with a higher density of carbon fibers.

[0068] The most important aspects of this invention can be summarized in:

[0069] gentle treatment of the fibers within the trickle zone while being mixed homogeneously,

[0070] prevention of fiber breaks,

[0071] production of a homogeneous isotropic non-woven mat or fleece.

[0072] In the following, exemplary embodiments of the invention will be explained in greater detail with reference to the accompanying drawings.

[0073] Therein:

[0074] FIG. 1 is a schematic representation of a first embodiment of the inventive device for manufacturing a two-dimensional non-woven fabric;

[0075] FIG. 2 is a schematic representation of a second embodiment of the inventive arrangement for manufacturing a two-dimensional non-woven fabric;

[0076] FIG. 3 is a detailed representation of an embodiment of the air shaft in a side view;

[0077] FIG. 4 is a detailed representation of the air shaft in accordance with the illustrative embodiment according to FIG. 3 in a schematic front view;

[0078] FIG. 5 shows a detailed representation of the air shaft in accordance with an embodiment corresponding to FIG. 3 and FIG. 4 is a schematic plan view;

[0079] FIG. 6 is a schematic representation of a third embodiment of the inventive device for manufacturing a two-dimensional non-woven fabric; and

[0080] FIG. 7 is a schematic representation of an embodiment of the inventive device for producing a three-dimensional non-woven fabric.

[0081] In FIG. 1 a schematic representation of a first embodiment of the device according to the invention for producing a two-dimensional non-woven fabric 5, wherein the non-woven fabric has thermal bonding fibers 51 fused on the surface.

[0082] The device includes an air shaft 1 with a lower end 11 and an upper end 12. Inside the air shaft 1 there are air rollers fitted with air nozzles 14, with direction of rotation indicated with R. The rotation of the air rollers 14 takes place by means not shown electric motors, arranged on the outside of the air shaft 1. At the upper end of the air shaft in the area of the port 43 is an inlet pivot-nozzle distributor device 121, which promotes better admission and better guidance in the air shaft 1. In the side walls of the air shaft 1 shaft-pivot-nozzle distributor 122 are provided, which effect also with compressed air a better fiber distribution. The pivoting nozzle manifolds 121, 122 are in this case provided automatically pivoting.

[0083] Next, at the lower end 1 of the air shaft, a heat source 15 is provided, which may be embodied as infrared radiating, microwave radiating or the like.

[0084] Below the air shaft 1, which namely serves for the percolation or trickling of separated fibers, namely carbon fibers as the main component, a laying surface 2 is formed in the form of a depositing conveyor belt 21, wherein the depositing conveyor belt is formed with perforations and has a suctioning withdrawing of air, or for vacuum assisted depositing of the fibers onto the depositing conveyor belt 21.

[0085] Following the depositing conveyor belt 21 a non-woven fabric removal conveyor belt 22 is provided.

[0086] Further, the device includes an opener 3, shown here as a classic opener with two counter-rotating needle rollers. The opener 3 is supplied by a supply of carbon fibers 31, in particular from recycled carbon short fibers. The carbon fibers are here transported by conveyor 312 to the opener 3. Next, a supply of thermal binder fibers 32, for example, polyamide fibers, is provided parallel thereto, which fibers are conveyed via a conveyor 322 to the opener 3.

[0087] The device further includes a pipeline system 4, which allows the opened fibers to be conveyed from the opener 3 to the air shaft 1. The piping system 4 includes, in addition to the transport pipes, which are formed as spiral ducting, a transport fan 41, a calming pipe section 42, this

being designed as a perforated plate with a vacuum envelope, and an introduction section 43, wherein the introduction section 43 forms a transition from a round tube to a square introduction section at the upper end 12 of the air shaft 1.

[0088] Next, the sequence of the non-woven fabric production is illustrated by this figure:

[0089] First, thermal bonding fibers and carbon fibers are transported on conveyors 312, 322 in accordance with the direction of transport X_{TF} and X_{CF} from the respective stocks 31, 32 to the opener 3. In the opener 3 the opening of fibers is carried out in the traditional manner by counter-rotating needle rollers. In a specific embodiment, the needle rollers have a round or hemispherical head region.

[0090] After opening, the fibers are introduced laterally into the pipe system 4 in such a manner that the fibers are transported in the direction of transport XO (into the plane of the figure) through the pipeline system 4 with swirling parallel to the opener 3 whereby the singled out or opened fibers are free to move along.

[0091] A transport fan 41 is provided for transportation of the fibers in the direction of transport X_F through the circular part of the pipeline system 4.

[0092] In addition, to calm the fibers, a calming pipe section 42 is provided, where air exits through the holes of the perforated metal pipe. Here, the air can also be suctioned out via a further closed tube element enclosing a perforated tube.

[0093] After the calming of the fibers, the introduction of the fibers into the air shaft 1 takes place through the introduction section 43.

[0094] Inside the air shaft 1, the fibers trickle downwards due to gravity and by suction below the depositing conveyor belt 21. Here, the fibers are mixed exclusively non-contact, by means of an aerodynamic air mixing system, namely, an array of air five rollers 14, which are arranged in the lower region of the air shaft 1.

[0095] After the aerodynamic and non-contact mixing of the fibers, these trickle through rollers 14 to the depositing conveyor belt 21, wherein this is amplified by the corresponding suction below the depositing conveyor belt 21.

[0096] The depositing conveyor belt 21 continuously moves on so that initially a non-woven fabric 5 is produced. The non-woven fabric 5 comprising carbon fiber and thermal bonding fibers, present in a homogeneous mixture, is conveyed to a heat source 15, where the web is superficially solidified by melting the thermal bonding fibers 51.

[0097] Furthermore, a transfer of the non-woven fabric 51 to a web transport conveyor 22 is effected.

[0098] In the following the same reference numerals are used for like components, and reference is made to their fundamental function to the previous embodiments.

[0099] FIG. 2 shows a schematic representation of a second embodiment of the inventive device for manufacturing a two-dimensional non-woven fabric 5 consisting solely of carbon fibers.

[0100] In this embodiment, only carbon fibers are supplied to the opener 3 and accordingly fed to the air shaft 1.

[0101] The air shaft 1 has, in this embodiment, two levels of air rollers 14, 16, which are each arranged horizontally in the air shaft 1. The upper level air rollers 16 first cause a pre-mixing of the fibers within the calmed air shaft 1 and then supply the already relatively homogeneously to the lower air roller device 14.

[0102] What is important to all the embodiments of this application is the contactless handling of the carbon fibers

within the air shaft **1** by means of air rollers **14**, **16**, **19** and air nozzles **121**, **122**. Graphically illustrated as the air rollers **14**, **16**, **19** is always the rotating air roll per se as well as the air flows emerging from the nozzles arranged on the rotating air rollers.

[0103] After the settling of the carbon fibers on the depositing conveyor belt **21**, facilitated by the generated suction, the homogeneous non-woven fabric **5** is moved in the transport direction X_V and past on to the removal conveyor belt **22**.

[0104] In FIG. **3** a detailed representation of an embodiment of the air shaft **1** is shown in a side view.

[0105] The duct **1** has again two levels of air rollers **14** and **16**, wherein in this embodiment three horizontally arranged air rollers are arranged side by side, which are also supported by baffles **17** on the edge of the air shaft **1**, so that the trickling of the carbon fibers occurs in a more concentrated manner.

[0106] FIG. **4** is a detailed representation of the air shaft **1** according to the embodiment shown in FIG. **3** illustrated in a schematic front view.

[0107] Here, the differently designed nozzles of the air rollers **14**, **16** can be seen. The nozzles of the air rollers **14**, **16** are shown arranged near the upper side only by way of example, they are however in a preferred embodiment located circumferentially on all sides on the surface of the air rollers **14**, **16**, so that mixing can be achieved in the entire duct **1**.

[0108] In FIG. **5** a detailed representation of the air shaft **1** according to the embodiment corresponding to FIG. **3** and FIG. **4** is shown in a schematic plan view.

[0109] In FIG. **6** a schematic representation of a third embodiment of the inventive device for manufacturing a two-dimensional non-woven fabric **5** is shown.

[0110] In this embodiment, the carbon fibers are trickled onto the laydown conveyor **21** by means of the inventive device, analogous to FIG. **2**. Herein, the mixing takes place inside the air shaft **1** by means of air rollers **14** or appropriately arranged nozzles.

[0111] The thermal bonding fibers are supplied subsequent to the application of the carbon fibers via a separate duct, in which duct the thermal bonding fibers are homogenized and mixed via known prior art needle rollers.

[0112] Subsequently, the layered fibers, namely the carbon fibers at the bottom of and the thermal binder fibers above, are supplied to a heat source **15**, which partially melts the thermal bonding fibers, so that a carbon non-woven fabric **5** is formed with an almost solid surface made from partially fused thermal bonding fibers **51**.

[0113] FIG. **7** is a schematic representation of an embodiment of the device according to the invention for producing a three-dimensional non-woven fabric.

[0114] In this embodiment, the embodiment of FIG. **1** is again generally incorporated, wherein carbon fibers and thermal bonding fibers mixed together and homogenized in the duct **1** and are sprinkled onto a laying surface **2**.

[0115] Within the air shaft **1** now three roll air levels **14**, **16**, **19** are provided, which are each different. There occurs respectively an improved separation and mixing of the fibers, which are then ultimately sprinkled onto a three-dimensional shape to be covered **23**.

[0116] The three-dimensional shape to be covered **23** is disposed on a multi-axis robotic arm **24** so that the mold, starting one side, is guided past the trickle zone of the air shaft **1**. Here, the mold **23** is so guided past with the aid of the robot arm **24**, which is driven for example via a corresponding

software programmable controller, so that the trickling fibers are trickled perpendicular to each point of the three-dimensional shape **23**.

[0117] In order that the settled deposited fibers not slip or even fall off during further movement of the mold **23** by means of the robot arm **24**, by means of the heat source **15** a partial melting of the thermal bonding fibers to the surface is accomplished, so that a non-woven fiber **51** is produced on the three-dimensional shape **23**.

[0118] All produced webs **5**, **51** can be further processed with appropriate processing method, so that, for example, carbon fiber reinforced plastic components arise.

LIST OF REFERENCE NUMBERS

- [0119] **1** airshaft
 - [0120] **11** lower end
 - [0121] **12** upper end
 - [0122] **121** inlet pivot-nozzle distributor
 - [0123] **122** shaft pivot-nozzle distributor
 - [0124] **13** over-pressure vent
 - [0125] **14** air rollers with fitted air nozzles/air nozzles
 - [0126] **15** heat source/infrared radiator/microwave radiator
 - [0127] **16** second row of air rollers fitted with air nozzles
 - [0128] **17** air deflectors or baffles
 - [0129] **18** airshaft with nails rolls
 - [0130] **19** third row of air rollers fitted with air nozzles
 - [0131] **2** laying surface
 - [0132] **21** depositing conveyor belt with suction
 - [0133] **22** non-woven fabric removal conveyor belt
 - [0134] **23** mold to be covered
 - [0135] **24** robotic arm
 - [0136] **3** opener
 - [0137] **31** supply of carbon fiber/recycled-carbon short fibers
 - [0138] **312** conveyor device for carbon fibers
 - [0139] **32** supply of thermal binder fiber/polyamide fibers
 - [0140] **322** conveyor device for thermal bonding fibers
 - [0141] **4** pipe system
 - [0142] **41** transport ventilator
 - [0143] **42** calming section/perforated sheet
 - [0144] **43** introduction section
 - [0145] **5** non-woven fabric
 - [0146] **51** non-woven fabric with superficially fused thermal bonding fibers
 - [0147] R rotation of air rollers
 - [0148] X_B transport direction calmed fibers
 - [0149] X_{CF} transport direction carbon fibers from supply to opener
 - [0150] X_{TF} transport direction thermal bonding fibers from supply to opener
 - [0151] X_O transport direction of the fibers subsequent to the opener (parallel to the opener and circular motion)
 - [0152] X_F transport direction fibers (in the circular section)
 - [0153] X_V transport direction depositing conveyor belt with fleece
 - [0154] X_L main transport direction of the carbon fibers/thermal bonding fibers within the air shaft
- I. A process for producing a carbon fiber non-woven fabric from carbon fibers up to a fiber length of 100 mm, comprising the steps of:
 - I. supplying carbon fibers;
 - II. loosening/combing and aerodynamic separating the carbon fibers;
 - III. aerodynamic calming the separated carbon fibers;

IV. introducing the calmed and isolated carbon fibers into a vertically arranged air shaft (1), wherein the introduction takes place at the upper end (12) of the air shaft (1);

V. contactless mixing the carbon fibers within the air shaft (1) by means of a plurality of individual air swirling air streams;

VI. aerodynamic depositing the carbon fibers onto a moveable mold or a laying surface (2) arranged below the air shaft (1), wherein the aerodynamic depositing is facilitated by a suction below the mold or the laying surface (2),

wherein

the air flows are varied or adjusted in their direction and/or strength, and

the air currents are produced and varied by one or more rotating and horizontally arranged air nozzles (14).

2. The process according to claim 1, wherein the suctioning (step VI.) is varied and/or adjusted in the suction power.

3. The process according to claim 1, wherein the mold or the laying surface (2) is passed under the lower outlet (11) of the air shaft (1), wherein the passing is guided linear or spatially, and wherein the normal surface of the shape or laying surface (2) corresponds in sections to the perpendicular of the air shaft (1).

4. The process according to claim 1, wherein the carbon fibers are cut during feeding by means of a cross-cutter.

5. The process according to claim 1, wherein any one of the preceding claims,

the carbon fibers are supplemented by thermal bonding fibers during feeding.

6. The process according to claim 5, wherein after the application of the mixture consisting of carbon fibers and thermal bonding fibers to mold or laying surface (2), the thermal bonding fibers are partially melted by application of energy.

7. A carbon fiber non-woven fabric production device for carbon fibers up to a fiber length of 100 mm, to carry out the carbon fiber non-woven fabric manufacturing processes according to claim 1,

comprising:

- a supply arrangement for carbon fibers and, optionally, a supply arrangement for thermal binding fibers;
- a loosening/combing apart device or a fiber opener for combing, separating, loosening and/or releasing the carbon fibers;
- an air shaft (1), wherein this is arranged vertically and wherein the carbon fibers are introduced at its upper end (12) and discharged at the lower end (11);
- a transport and separation device for separating and transporting the separated carbon fibers from the loosening/combing apart device or the fiber opener to the air shaft (1), including:

including:

- a pipeline system (4);
- an entry area of the pipeline system (4) to the loosening/combing apart device or a fiber opener;
- a transport fan (41) inside the pipeline system for transport of the carbon fibers to the air shaft;
- a calming section (42), arranged downstream of the transport fan (41), designed as a perforated tube, and
- an introduction section (43) for the introduction of the carbon fibers into the air shaft (1);

a perforated deposit surface (2) arranged at the lower end (11) of the air shaft (1), in particular a conveyor belt, or a three dimensional shape for giving form to the carbon fibers to be deposited thereon;

a vacuum provided below the deposit shape or surface (2), and

an aerodynamic mixing system arranged in the air shaft (1) for mixing the carbon fibers wherein

the aerodynamic system comprises a plurality of air nozzles (14) which generate a plurality of air streams, wherein the air streams are variable and/or adjustable in their direction and/or strength.

8. The device according to claim 7, wherein the air nozzles (14) are rotated around one or more axes and/or swiveled and/or are designed differently in their nozzle outlet.

9. The device according to claim 7, air nozzles (14) are arranged on horizontally arranged and rotating rollers.

10. The device according to claim 7, wherein the neck area and/or the pipe section has interior grooves and/or baffles which cause a circular movement of the carbon fibers.

11. The device according to claim 7, wherein a robot arm device is provided below the air shaft (1) for the movement of the mold, wherein the robotic arm device allows three-dimensional movement of the mold below the air shaft (1).

12. The device according to claim 7, wherein a heat source (15) is arranged at the lower end (11) of the air shaft (1) so that the thermal bonding fibers can be heated after application to the mold or the laying surface (2).

13. A three-dimensional non-woven component manufacturing method for manufacturing a non-woven fabric for a three-dimensional part using a carbon fiber non-woven fabric production device according to claim 7, wherein

- a three-dimensional mold of the component to be produced is guided past a fiber output such that the fibers applied from the fiber output onto the site of deposit are applied in the orientation normal to the surface of the mold.

14. The method according to claim 13, wherein the speed of movement of the mold and/or a suction of the device below the mold is varied.

15. A non-woven fabric prepared by a carbon fiber non-woven fabric production process according to claim 1.

* * * * *